National Aeronautics and Space Administration

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Ares Projects
AIAA Space 2008 Conference
September 10, 2008

The Ares Projects: Progress Toward Exploration

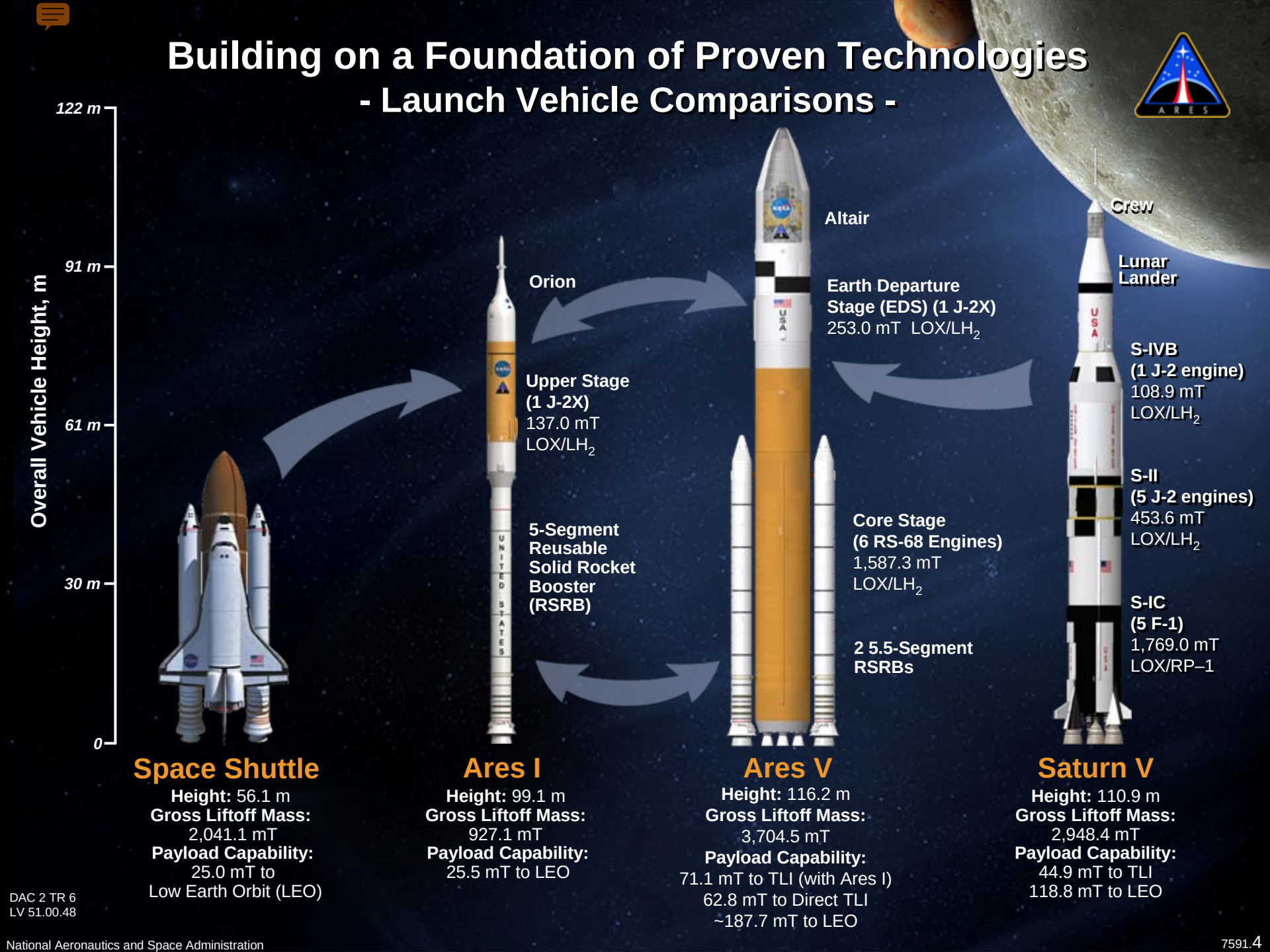
Agenda

- Projects Overview
- The Ares Vehicles and Mission
- Heritage and Commonality
- The Government/Industry Team
- Ares I Overview
- Vehicle Integration
- First Stage
- Upper Stage
- Upper Stage Engine
- Facility Upgrades
- Ares I-X Flight Test
- Upcoming Activities
- Ares V Overview
- Summary / Q&A

Projects Overview

- **Deliver crew and cargo for missions to International Space Station (ISS) and to Moon and beyond**
- **Continuing progress toward design, component testing, and early flight testing**
- **Ares I Crew Launch Vehicle**
  - Will carry 6 crew to ISS, 4 to Moon
  - First flight test 2009
  - Initial Operational Capability 2015
- **Ares V Cargo Launch Vehicle**
  - Will launch Earth Departure Stage (EDS) and Altair lunar lander to low Earth orbit for lunar missions
  - Largest launch vehicle ever designed
  - Will begin detailed development work in 2011

Building on a Foundation of Proven Technologies
- Launch Vehicle Comparisons -



Space Shuttle
Height: 56.1 m
Gross Liftoff Mass:
2,041.1 mT
Payload Capability:
25.0 mT to
Low Earth Orbit (LEO)

Ares I
Height: 99.1 m
Gross Liftoff Mass:
927.1 mT
Payload Capability:
25.5 mT to LEO

Ares V
Height: 116.2 m
Gross Liftoff Mass:
3,704.5 mT
Payload Capability:
71.1 mT to TLI (with Ares I)
62.8 mT to Direct TLI
~187.7 mT to LEO

Saturn V
Height: 110.9 m
Gross Liftoff Mass:
2,948.4 mT
Payload Capability:
44.9 mT to TLI
118.8 mT to LEO

DAC 2 TR 6
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Ares Nationwide Team

ATK Launch Systems

Ames

Marshall

Glenn

Langley

Pratt & Whitney Rocketdyne

Johnson

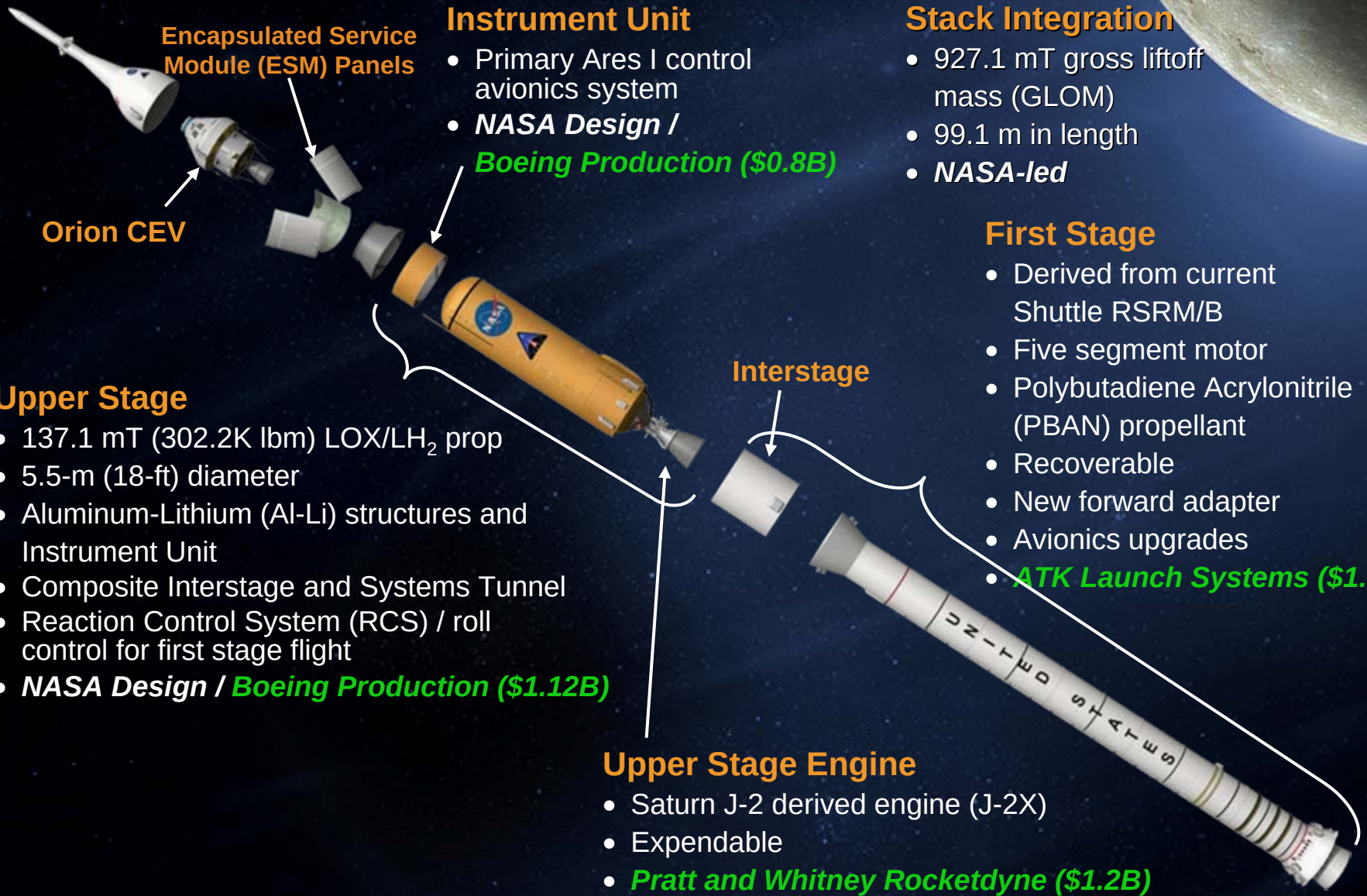
Boeing

Michoud Assembly Facility

Stennis

Kennedy

Ares I Elements



Instrument Unit

- Primary Ares I control avionics system
- ***NASA Design / Boeing Production ($0.8B)***

Stack Integration

- 927.1 mT gross liftoff mass (GLOM)
- 99.1 m in length
- ***NASA-led***

First Stage

- Derived from current Shuttle RSRM/B
- Five segment motor
- Polybutadiene Acrylonitrile (PBAN) propellant
- Recoverable
- New forward adapter
- Avionics upgrades
- ***ATK Launch Systems ($1.8B)***

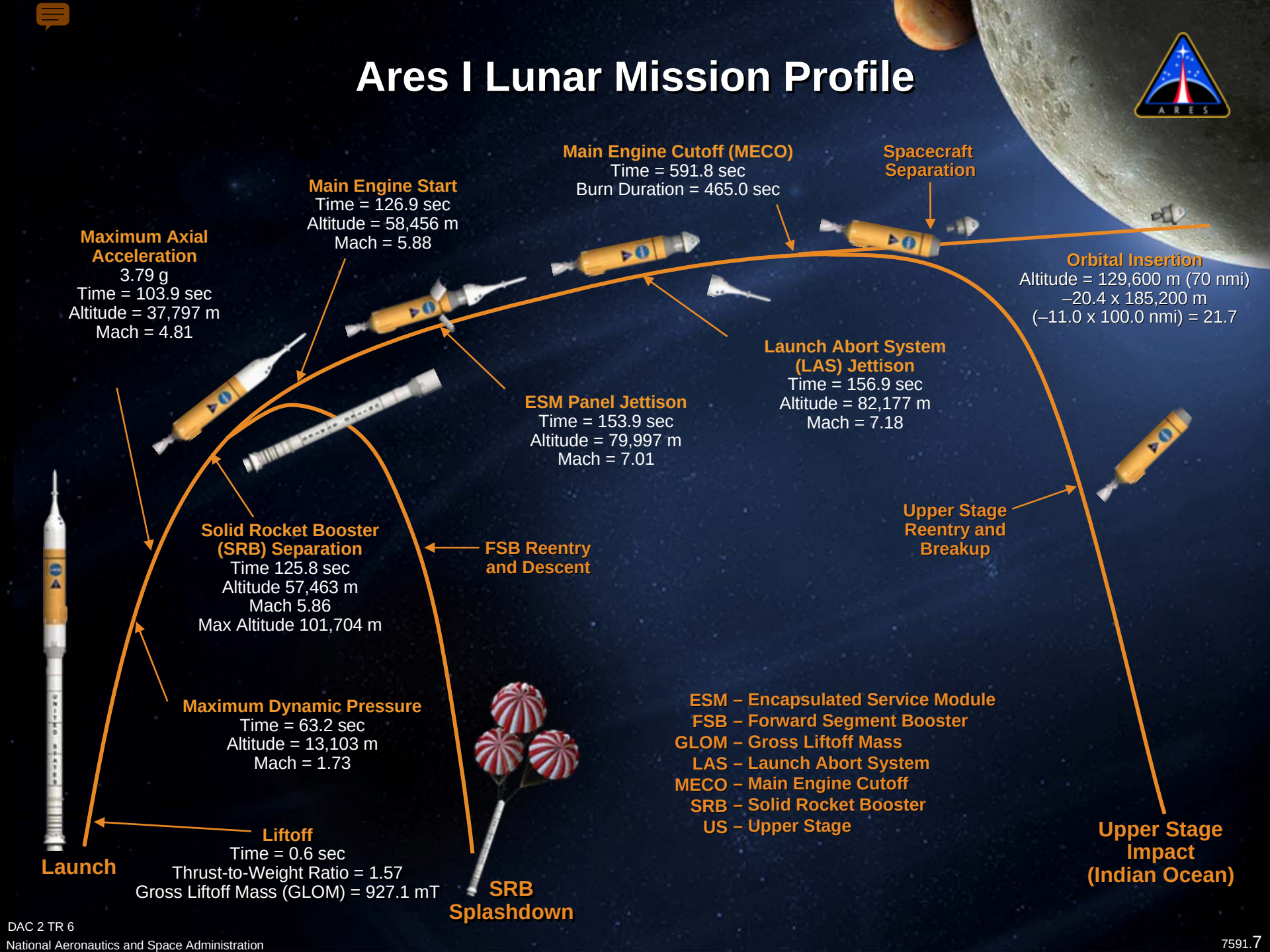
Upper Stage

- 137.1 mT (302.2K lbm) LOX/LH_2 prop
- 5.5-m (18-ft) diameter
- Aluminum-Lithium (Al-Li) structures and Instrument Unit
- Composite Interstage and Systems Tunnel
- Reaction Control System (RCS) / roll control for first stage flight
- ***NASA Design / Boeing Production ($1.12B)***

Upper Stage Engine

- Saturn J-2 derived engine (J-2X)
- Expendable
- ***Pratt and Whitney Rocketdyne ($1.2B)***

Ares I Lunar Mission Profile



Ares I Configuration Progression

- Vehicle design and flight profile adjusted to accommodate new Alternate Launch Abort System (ALAS 11) and Encapsulated Service Module (ESM) separation panels
- New common bulkhead upper stage propellant tanks
- Modified First Stage Booster (FSB) forward skirt
- FSB separation motors moved to aft skirt
- Single fault tolerant avionics

Vehicle Integration

- **Responsible for Ares I integrated vehicle reviews, including SDR, completed October 2007**
- **Conducting wind tunnel testing for overall vehicle**
- **Conducted 6,000 hours of wind tunnel testing (~70% of planned development testing)**
- **1/2% First Stage Reentry Wind Tunnel Test**
  - Helps calibrate Ares I first stage Altitude Switch Assembly (ASA) or “baroswitch,” which deploys parachute recovery system
- **Stage Separation Wind Tunnel Test**
  - Allows design team to better understand aerodynamic properties, relative motions, and other events
- **Other Wind Tunnel Testing**
  - Evaluated high- and low-speed aerodynamic flows

Vehicle Integration Accomplishments

Ares 4% Model Aeroacoustices Wind Tunnel Test
Ames research Center, CA

Ares 1% Model Transonic Wind Tunnel Test
Langley Research Center, VA

Dynamic Test Stand Renovations
Marshall Space Flight Center, AL

First Stage

Composite Frustum

Tumble Motors (from Shuttle)

Modern Electronics

12-Fin Forward Segment

Same propellant as Shuttle (PBAN)–Optimized for Ares Application

Same cases and joints as Shuttle

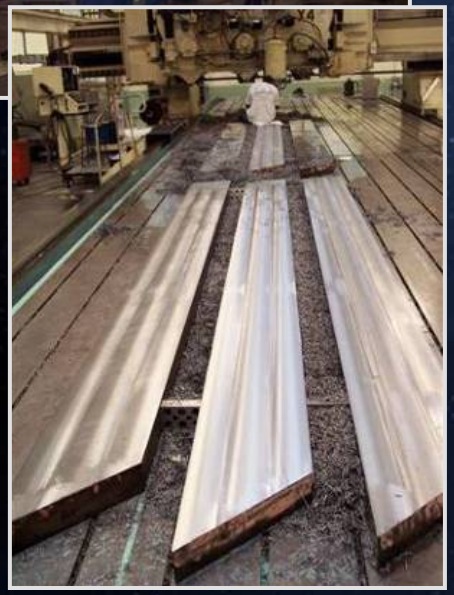
Booster Deceleration Motors (from Shuttle)

Wide Throat Nozzle

Same Aft Skirt and Thrust Vector Control as Shuttle

Mass: 733 mT
Thrust: 15.8 MN
Burn Duration: 126 sec
Height: 53 m
Diameter: 3.7 m

First Stage



- 5-segment reusable solid rocket motor based on Shuttle 4-segment motor
- Primary propulsion for Ares I, part of Ares V first stage propulsion
- Fabrication of Development Motor (DM–1) and process simulation articles underway
- Expendability trade study – will continue recovering/reusing motor
- Composite hardware for non-reusable structures, metal for reusable structures

First Stage Accomplishments

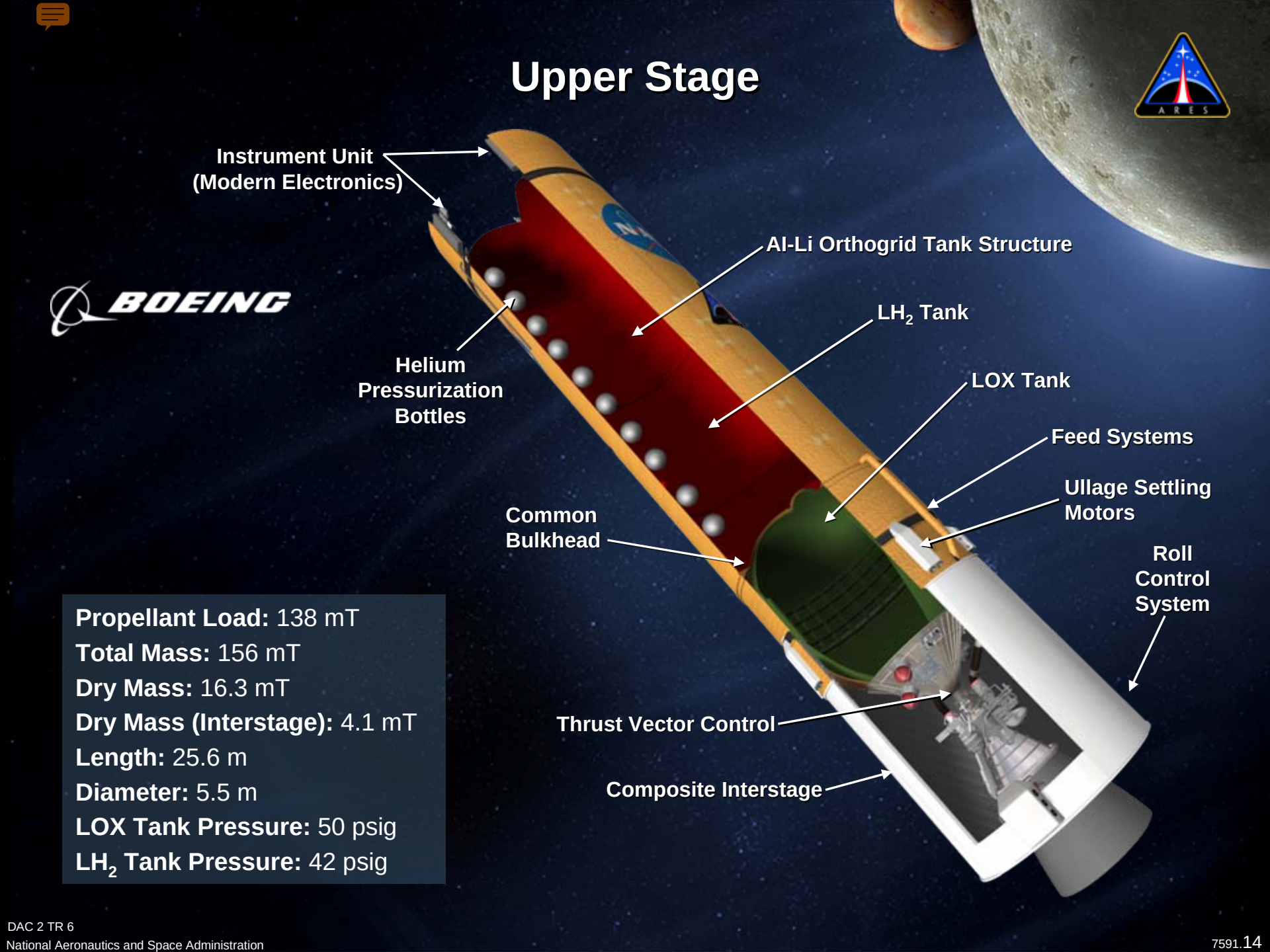
First Stage DM-1 Nozzle Fabrication
Promontory, UT

First Stage Fin Installation and Removal Testing
Promontory,UT

First Stage Forward Segment Propellant Casting
Promontory, UT

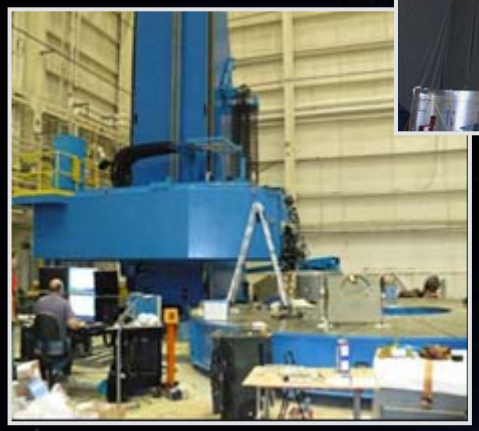
First Stage Forward Core Fin Removal
Promontory, UT

Upper Stage



Propellant Load: 138 mT
Total Mass: 156 mT
Dry Mass: 16.3 mT
Dry Mass (Interstage): 4.1 mT
Length: 25.6 m
Diameter: 5.5 m
LOX Tank Pressure: 50 psig
LH_2 Tank Pressure: 42 psig

Upper Stage

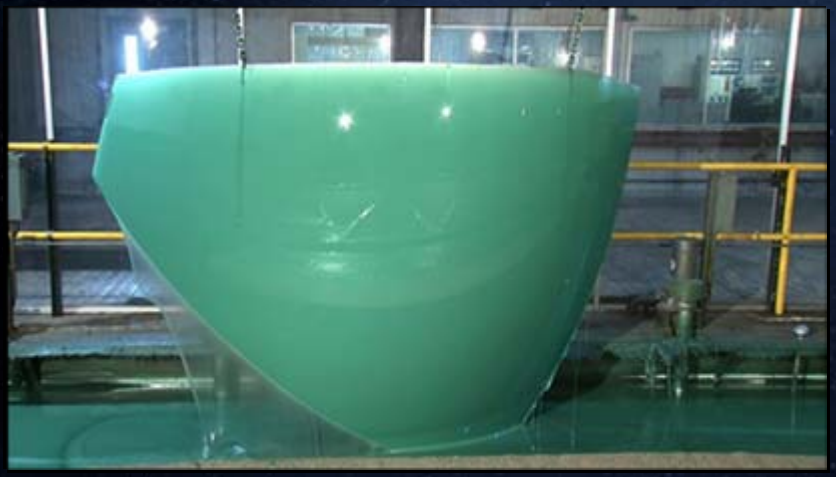


- Prime contractor selected for upper stage production and instrument unit
- Initial units manufactured at Marshall Space Flight Center (MSFC), production units at Michoud Assembly Facility (MAF)
- Main Propulsion Test Article (MPTA) to be tested at MSFC
- PDR kick-off June 2008
- Using State of the Art CAD modeling to support design and production system
- Demonstrating new robotic weld tool and vertical weld tools at MSFC
- Will be used to manufacture Manufacturing Demonstration Articles (MDAs) of Aluminum-Lithium (Al-Li) gore panels for Ares I upper stage
- Robotic weld tool is high-precision friction stir welding tool for welding dome portions of upper stage tanks
- Vertical weld tool will perform longitudinal barrel welds
- System checkout currently ongoing

Upper Stage Accomplishments

DELMIA Simulation of Interstage Mock-Up
Marshall Space Flight Center, AL

MPTA Manufacturing Process with DELMIA Simulation Overlays
Marshall Space Flight Center, AL



Dome Gore Panel Chemical Milling
Los Angeles, CA

J-2X Engine

Used on Ares I and Ares V

Turbomachinery
- Based on J-2S MK-29 design

Flexible Inlet Ducts
- Based on J-2 & J-2S ducts

Gas Generator
- Based on RS–68 design

Open-Loop Pneumatic Control
- Similar to J-2

Engine Controller
- Based directly on RS-68 design and software architecture

HIP-bonded MCC
- Based on RS-68 demonstrated technology

Regeneratively Cooled Nozzle Section
- Based on long history of RS-27 success

Metallic Nozzle Extension
- New design

Mass: 2.5 mT
Thrust: 131 mT (vac)
Isp: 448 sec (vac)
Height: 4.7 m
Diameter: 3.05 m

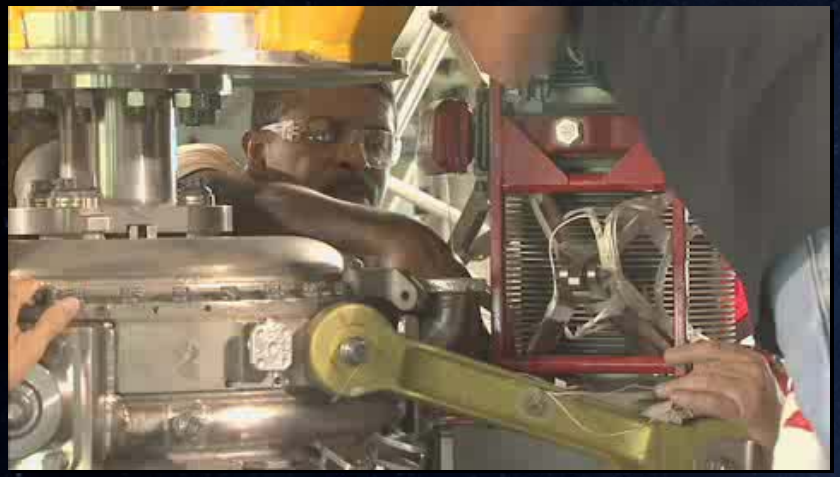
Pratt & Whitney
A United Technologies Company

Pratt & Whitney Rocketdyne, Inc.

Upper Stage Engine

- Provides upper stage propulsion for Ares I and Ares V as well as trans-lunar injection burn for lunar missions
- Derived from Saturn V second- and third-stage engines, but incorporates technologies from RS-68 and Space Shuttle Main Engines
- Engine in design
- Testing turbopump and gas generator powerpack at Stennis Space Center (SSC)
- Testing gas generator at MSFC
- Testing subscale diffuser
- Building altitude test stand at SSC

Upper Stage Engine Accomplishments



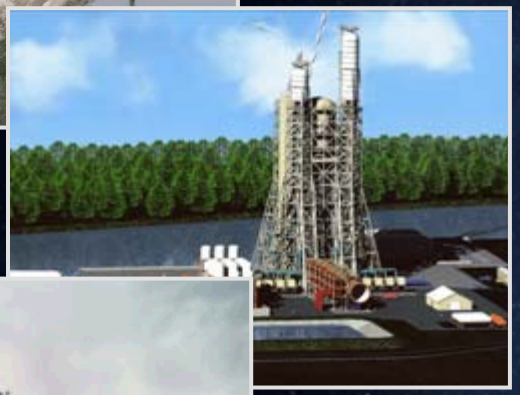
J-2X Powerpack Removal from A-1 Test Stand
Stennis Space Center, MS

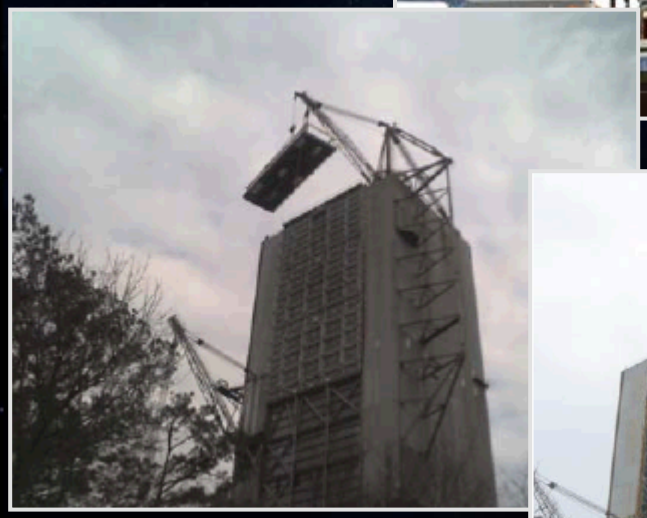
J-2X Workhorse Gas Generator Manufacturing
Canoga Park, CA

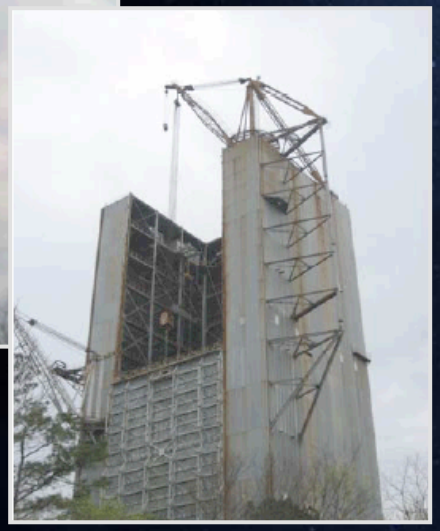
J-2X Workhorse Gas Generator Test Firing
Marshall Space Flight Center, AL

E3 Subscale Diffuser Test
Stennis Space Center, MS

Facility Upgrades – Structures and Dynamics







- **SSC A-3 Test Stand**
  - First NASA test stand ever built for altitude testing
  - Will be used to conduct development and certification engine testing
  - Tests engine performance at simulated altitudes of 80,000 - 100,000 feet
  - Site clearing began in spring 2007
  - Structural piles driven and concrete forms and reinforcing bars in place to pour the foundation
- **MSFC Dynamic Test Stand Refurbishment**
  - Used to test Saturn and Shuttle
  - Will be used for Ares I and V Integrated Vehicle Ground Vibration Testing
  - Upgrading cranes and interior for use in 2011

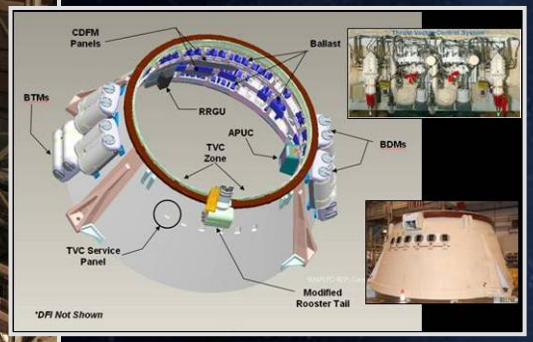
Ares I–X Test Flight

- **Demonstrate and collect key data to inform the Ares I design:**
  - Vehicle integration, assembly, and KSC launch operations
  - Staging/separation
  - Roll and overall vehicle control
  - Aerodynamics and vehicle loads
  - First stage entry dynamics for recovery

- **Performance Data:**

	Ares I-X	Ares I
First Stage Max. Thrust (vacuum):	14.1 MN	15.8 MN
Max. Speed:	Mach 4.7	Mach 5.84
Staging Altitude:	39,600 m	57,700 m
Liftoff Weight:	816 mT	927 mT
Length:	99.7 m	99.1 m
Max. Acceleration:	2.46 g	3.79 g

Ares I-X Test Flight

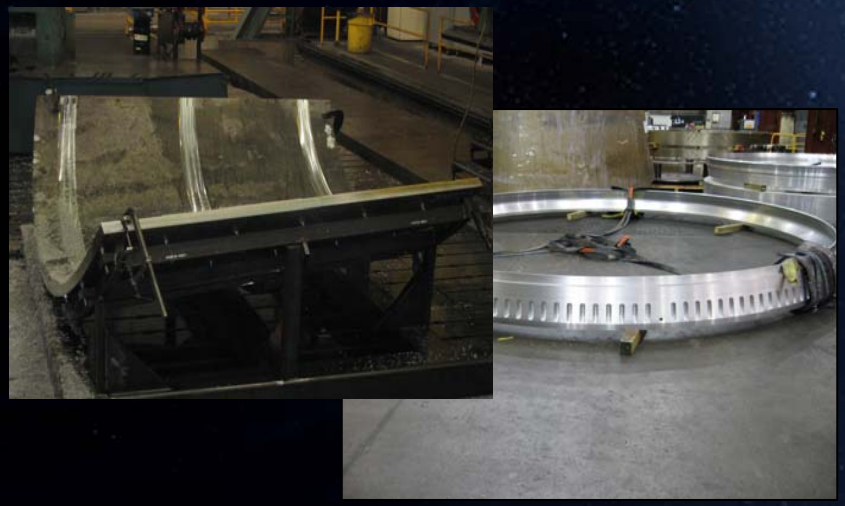


- First Ares I flight test (uncrewed)
- Will demonstrate ascent, separation, roll control, recovery, and ground capabilities
- Uses off-the-shelf, active, and simulator hardware
  - First stage propulsion, avionics, and roll control active systems
  - First stage forward structures, upper stage, Orion crew exploration vehicle, and Launch Abort System (LAS) instrumented mass simulator hardware
- Holding flight hardware deliveries to April 2009 launch date
- Launch date could be delayed due to availability of Mobile Launcher

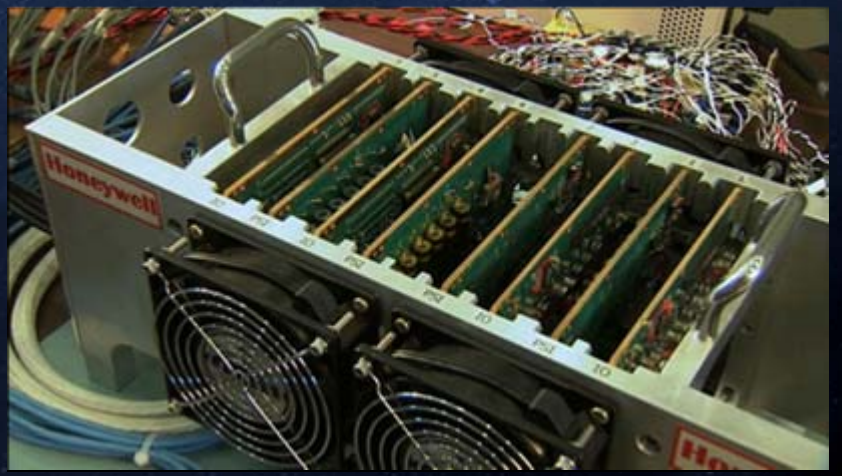
Ares I-X Accomplishments

Upper Stage Simulator Assembly
Glenn Research Center (GRC), OH

Roll Control System Test and Fabrication
Huntsville, AL and WSTF, NM

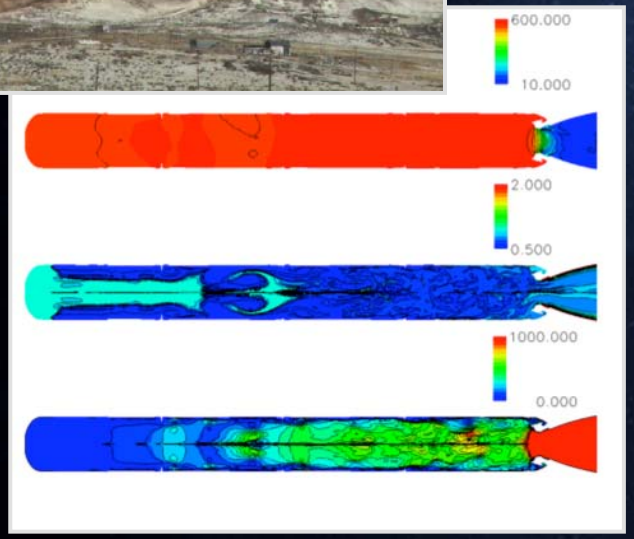


Forward Frustum Fabrication
Indianapolis, IN



First Stage Actuator Systems Testing
Marshall Space Flight Center, AL

Upcoming Activities



- **First 5-segment solid rocket motor for Ares vehicles will be tested at ATK Launch Systems in 2009**
  - Hardware already in fabrication
  - Shuttle processes improved for safety and efficiency
  - Data from test will inform future 5-segment motor designs
- **First stage thrust oscillation**
  - Developing design mitigation strategies to overcome first stage structure oscillation generated by propellant harmonics
  - First Stage Element Office working with MSFC Engineering Directorate and Orion Project Office
  - Mitigation to be identified by conclusion of Ares I PDR
  - Additional data to be collected during Ares I-X flight test and upcoming Shuttle flights (gathering thrust oscillation data on Shuttle)

Ares V Elements

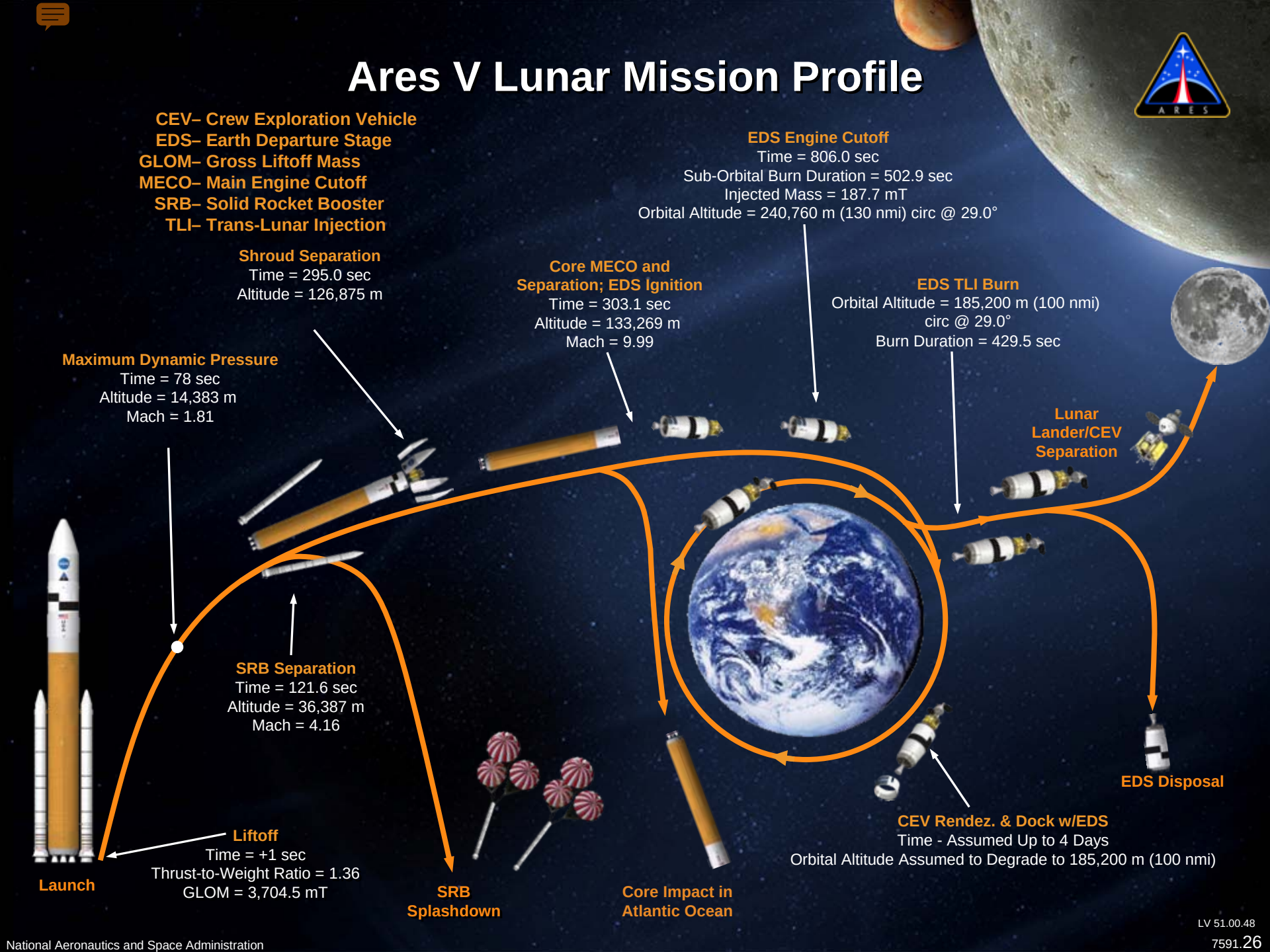
Stack Integration
- 3,704.5 mT gross liftoff mass (GLOM)
- 116.2 m in length

Solid Rocket Boosters
- Two recoverable 5.5-segment PBAN-fueled boosters (derived from current Ares I first stage)

Earth Departure Stage (EDS)
- One Saturn-derived J-2X LOX/LH_2 engine (expendable)
- 10-m diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, instrument unit and interstage
- Primary Ares V avionics system

Core Stage
- Six Delta IV-derived RS-68 LOX/LH_2 engines (expendable)
- 10-m diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks

Ares V Lunar Mission Profile



CEV– Crew Exploration Vehicle
EDS– Earth Departure Stage
GLOM– Gross Liftoff Mass
MECO– Main Engine Cutoff
SRB– Solid Rocket Booster
TLI– Trans-Lunar Injection

Shroud Separation
Time = 295.0 sec
Altitude = 126,875 m

Maximum Dynamic Pressure
Time = 78 sec
Altitude = 14,383 m
Mach = 1.81

Core MECO and Separation; EDS Ignition
Time = 303.1 sec
Altitude = 133,269 m
Mach = 9.99

EDS Engine Cutoff
Time = 806.0 sec
Sub-Orbital Burn Duration = 502.9 sec
Injected Mass = 187.7 mT
Orbital Altitude = 240,760 m (130 nmi) circ @ 29.0°

EDS TLI Burn
Orbital Altitude = 185,200 m (100 nmi)
circ @ 29.0°
Burn Duration = 429.5 sec

Lunar Lander/CEV Separation

SRB Separation
Time = 121.6 sec
Altitude = 36,387 m
Mach = 4.16

Liftoff
Time = +1 sec
Thrust-to-Weight Ratio = 1.36
GLOM = 3,704.5 mT

Launch

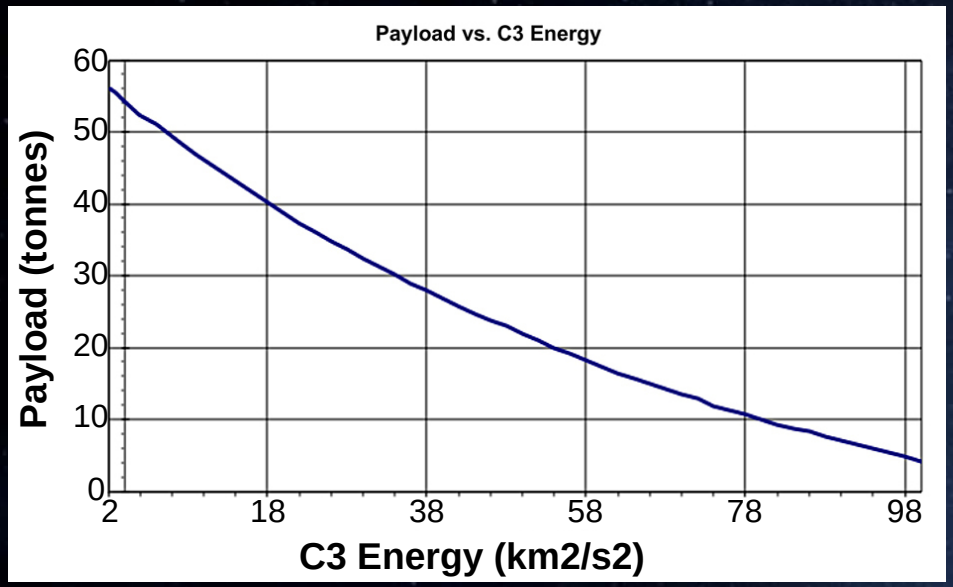
SRB Splashdown

Core Impact in Atlantic Ocean

EDS Disposal

CEV Rendez. & Dock w/EDS
Time - Assumed Up to 4 Days
Orbital Altitude Assumed to Degrade to 185,200 m (100 nmi)

Ares V Utilization Studies



- NASA has begun preliminary concept work on vehicle
- Focused on design of EDS, payload shroud, core stage, and RS-68 core stage engines
- Recent point-of-departure updated for additional performance margin using an additional RS-68 and an added 1/2 segment on the first stage
- Shroud size dictated by eventual size of Altair lunar lander
- Also investigating alternate uses for Ares V beyond human space exploration
  - Very large (8-meter aperture) science telescopes in low-Earth or Lagrange (L2) orbits
  - Capabilities could exceed Hubble by an order of magnitude

Projects Status

- Ares I successfully completed System Requirements Review (SRR) and System Definition Review (SDR)
- Ares I Preliminary Design Review (PDR) September 2008
- Element-level PDRs summer 2008
- J-2X Upper Stage Engine Critical Design Review (CDR) fall 2008
- Ares I-X flight hardware deliveries focused on April 2009
- Ares V Request for Information (RFI) release July 9, 2008, responses received August 4, 2008
- Ares V Configuration Updated at LCCR, June 2008

Summary

- Ares Projects making great strides toward building a new generation of launch vehicles
- Support ISS operations and human exploration of Moon and other destinations
- Ares I-X flight test in 2009
- Additional testing and development work in progress
- Ares launch vehicles continue on schedule to fulfill this strategic capability for the future
- Capabilities will develop in environment of increasing challenges
- NASA transitioning from performing space operations to expanding the Nation's frontiers

Questions?

www.nasa.gov/ares